

A NEW SMALL MINNOW MAYFLY (EPHEMEROPTERA: BAETIDAE) FROM UTAH, U.S.A.¹

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ABSTRACT: *Baetis moqui*, n. sp., is described from larvae collected from the Escalante Canyon Region of Garfield County in south-central Utah. The new species is unique among North American *Baetis* in having gill number one highly reduced or absent. Labial morphology and overall setation characteristics indicate a close relationship between *B. moqui* and the northern California species *Baetis alius* and the eastern North American species *Baetis pluto*. An updated key to the North American *Baetis* larvae is provided.

KEYWORDS: Ephemeroptera, Baetidae, *Baetis*, new species, Utah

Morihara and McCafferty (1979) provided the most recent revision of those North American small minnow mayfly species considered in the Arctogean (Holarctic + Oriental + Afrotropical) genus *Baetis* Leach. Since then, considerable phylogenetic research within the family Baetidae has led to an explosion of new genera and a further restriction of *Baetis* to selected species within the *Baetis* complex of genera, defined by two larval apomorphies: possession of a femoral villopore and flat-tipped setae on the antennal flagella, abdominal segments, and caudal filaments (Waltz and McCafferty 1987; Gaino and Rebora 1999).

Presently 21 North American species are considered within the genus *Baetis*, eight of which are known only from adults. In North America, most *Baetis* species are considered members of three species groups (Morihara and McCafferty 1979): The *fuscatus* group, which includes the species *Baetis carinus* Edmunds and Allen, *Baetis flavistriga* McDunnough, *Baetis intercalaris* McDunnough, *Baetis notos* Allen and Murvosh, and *Baetis rusticans* McDunnough; The *rhodani* group, which includes the species *Baetis adonis* Traver, *Baetis bicaudatus* Dodds, *Baetis diablus* Day, *Baetis foemina* McDunnough, *Baetis magnus* McCafferty and Waltz, *Baetis palisadi* Mayo, *Baetis parallelus* Banks, *Baetis persecutor* McDunnough, *Baetis piscatoris* Traver, and *Baetis tricaudatus* Dodds; The *vermus* group, which includes *Baetis brunneicolor* McDunnough, *Baetis bundyae* Lehmkuhl, and *Baetis hudsonicus* Ide. The Northern California species *Baetis alius* Day, and the principally Appalachian species *Baetis pluto* McDunnough have never been assigned to any species group, although their adult male genitalia would seem to indicate a close relationship to those species considered within the *fuscatus* species group.

A new species is described from larvae collected from the Escalante Canyon Region of Garfield County in south-central Utah. This new species along with

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B. alius and *B. pluto* are hereby considered as members of the newly recognized *alius* species group based on similarities of the labium (elongate palpal segments, elongate glossae and paraglossae, submentum and mentum; palpal segment two with moderately developed distomedial projection and convex medial margin), and adult male genital forceps (forceps of generally *fuscatus* type, with segment one lacking a distinct distomedial protuberance).

Baetis moqui, NEW SPECIES

(Figs. 1-6)

Diagnosis. The highly reduced and often absent nature of gill 1 distinguishes *B. moqui* from all other North American *Baetis*. In North America, larvae of *Americabaetis* Kluge and *Diphetero* Waltz and McCafferty are the only other Baetidae that lack gill 1. The distinct structure of the labial palpi will also serve to distinguish *B. moqui* from all other North American *Baetis* with the exception of *B. alius*. The wide first denticles of the mandibular incisors (Figs. 2 and 3); apically narrower, distomedially projecting paraglossae (Fig. 4); abdominal tergal patterning; and reduced or absent gill 1 (Fig. 5) of *B. moqui* will serve to distinguish it from the larvae of *B. alius*. Additionally, the dorsal setae of labial palpi segment two (Fig. 13) in *B. alius* tend to be arranged in a vertically oriented straight line, whereas those of *B. moqui* usually have a more or less clumped arrangement (Fig. 4). Mouthpart setation has proven to be considerably variable within most mayflies, thus the above feature may be of limited use.

Description of the larva. Body length: 5.8-7.0 mm, cerci 4.5-5.2 mm, medial caudal filament 2.8-3.2 mm. Head: Head capsule almost entirely brown, frontal and region around epicranial suture usually pale. Antennae extending to at least first abdominal segment; scape and pedicel brown, flagella pale with brown apices. Labrum as in Figure 1. Maxillae with 2-3 crest setae; palpi extending beyond galealacinal crest, segment 1 subequal to segment 2. Mandibular incisors as in Figures 2 and 3; first denticle broad, approximately as wide as denticle 2 and 3 combined. Labium as in Figure 4. Labial palpi segment 2 with 5-7 dorsal setae and well developed distomedial expansion with roughly convex inner margin. Thorax: Notula with extensive dark and pale markings. Hindwingpads well developed. Legs (Fig. 6) with dorsal margin of femora with long, stout setae; ventral margin with short stout setae; outer surface with numerous stout setae; inner surface with very sparse short, stout setae; dorsal margin of tibial and tarsi with very short stout setae; ventral margin with longer stout setae; femora with broad, medial, brown band and dark brown distally. Claws with 9-13 denticles. Abdomen: Gill 1 highly reduced or absent, when present similar to Figure 5. Gills 2-7 elongate; gill 4 with greatest length. Terga 1 with posterior three-fourths dark brown, anterior fourth pale; terga 2-4 entirely dark brown with large pale, paired, submedial round areas, pale anterolateral corners, and often with pale, vertically oriented, medial band; terga 5-6 mostly pale with darkened posterolateral corners and often some dark medial patterning; terga 7-8 entirely dark brown except pale anterolateral corners; terga 9-10 generally pale, occasionally with some minor medial brown patterning. Sterna pale brown with weak tracheation marks; sterna 7-8 dark brown giving segments 7 and 8 banded appearance. Caudal filaments pale with darkened apices and often darkened basally.

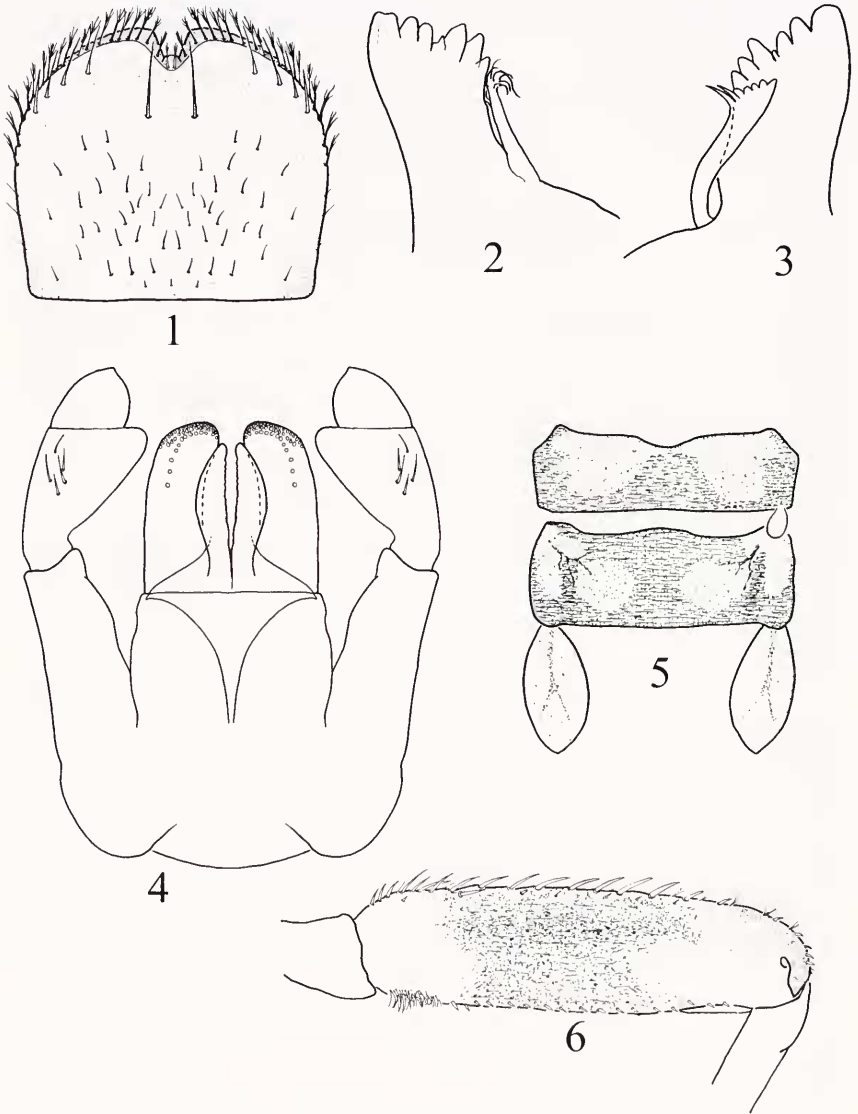
Type Material. HOLOTYPE: male larva, UTAH: Garfield Co., North Creek, above North Creek Reservoir, 8.2 mi from Hwy 12, North Creek Road, July 09, 2001, K. F. Kuehn (deposited in the Purdue University Entomological Research Collection). PARATYPES: 10 larvae same locality and deposition as holotype; 2 larvae, North Creek, above North Creek Reservoir, 7 mi from Hwy 12, North Creek Road, July 06, 2001, K. F. Kuehn (deposited in Monte L. Bean Life Science Museum, BYU).

Additional Material. UTAH: Garfield Co., Pine Creek, Box Death Hollow trailhead, Pine Creek Road, June 28, 2001, K. F. Kuehnl (20 larvae, personal collection of NAW and BYU).

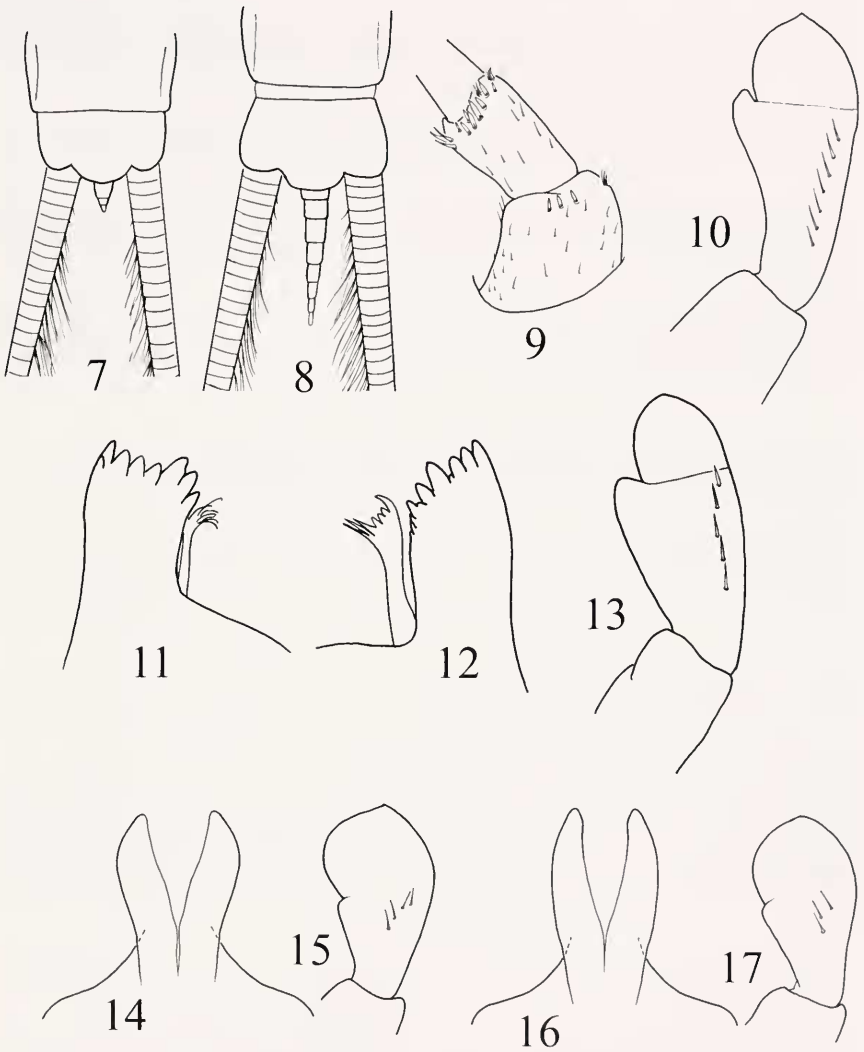
Specific Epithet. Moqui is an early name attributed to the Hopi (Hopati = peaceful ones) tribe of Pueblo Indians.

Remarks. *Baetis moqui* larvae have been collected from cold, clear water streams draining high elevation peaks (~3000 m) dominated by spring snowmelt and summer monsoonal rain events. Within these streams *B. moqui* larvae have been found on a variety of stream substrates including leaf packs and submerged vegetation along stream margins, but most commonly on fast flowing rocky substrates including leaf packs and submerged vegetation along stream margins, but most commonly on fast flowing rocky substrates within a coarse sand matrix. *Baetis moqui* were also commonly collected at a lower elevation (~2250 m to ~2100 m) from North and Pine Creeks and were not collected at the confluence of either stream with the Escalante River or at elevations above 2250 m. In addition, *B. moqui* was apparently absent from several similar adjacent streams including Sand, Boulder, Deer, Steep, and Calf Creeks, which were sampled and the presence of *B. moqui* was not detected at any elevation. Overall benthic macroinvertebrate community structure was similar between both North and Pine Creeks. Ecological associates found commonly with *B. moqui* include *B. tricaudatus*, *B. bicaudatus*, and *Ephemerella dorothea infrequens* McDunnough and several species of common western North American stoneflies including *Pteronarcella badia* (Hagen), *Isoperla* sp., *Sweltsa coloradensis* (Banks), and *Amphinemura* sp.

The geological formations where these streams flow are typical for southern Utah, with both streams flowing largely over various sandstones. North Creek originates on the Aquarius Plateau (~3000 m) and traverses through the Wahweap Formation (light gray to white, medium- to coarse-grained sandstone), Straight Cliffs Formation (light gray to white, medium- to coarse-grained sandstone) and finally through more recent alluvial terrace deposits as it enters the Escalante River (Doelling and Willis 1999). The headwaters of Pine Creek are located on Boulder Mountain (~3000 m) where it starts its ascent through Navajo sandstone (light-gray-orange, white, and pink medium-grained sandstone) then through the Carmel Formation and Entrada sandstones (white or pale orange fine to coarse-grained sandstone) before entering the Escalante River (Doelling and Willis 1999). Somewhat uncharacteristic of southern Utah, both North Creek and Pine Creek are clear water streams with low sediment loads. The Escalante River above and between these two creeks passes through substantial alluvium deposits and a thin layer of Tropic shale thus increasing the sediment load and overall turbidity within the river causing a white murky appearance.



Figures 1-6. *B. moqui*, n. sp.: 1. Labrum. 2. Right mandibular incisors. 3. Left mandibular incisors. 4. Labium. 5. Abdominal terga 1-2. 6. Femora.



Figures 7-17. Figs. 7-8, *B. bicaudatus*, posterior abdominal terga and partial caudal filaments. Figs. 9-10, *B. magnus*, 9. Antennal scape and pedicel. 10. Labial palpi. Figs. 11-13, *B. alius*, 11. Right mandibular incisors. 12. Left mandibular incisors. 13. Labial palpi. Figs. 14-15, *B. intercalaris*, 14. Glossae. 15. Labial palpi. Figs. 16-17, *B. flavistriga*, 16. Glossae. 17. Labial palpi.

KEY TO NORTH AMERICAN *BAETIS* LARVAE

The following key includes only those North American larvae presently considered within the genus *Baetis*. It is presented in order to complement the key found in Morihara and McCafferty (1979), not replace it. Identifications should still be confirmed by reference to the larval descriptions and diagnosis provided in Morihara and McCafferty (1979).

- 1a. Median caudal filament usually reduced to short stub (Fig. 6; Morihara and McCafferty 1979 Fig. 17f), occasionally up to approximately 0.2 length of cerci, distinctly tapering and without fringe of fine setae (Fig. 7) 2
- 1b. Median caudal filament at least 0.4 the length of cerci, lateral margins of median caudal filament more parallel in nature and with fringe of fine setae in at least apical half (Morihara and McCafferty 1979 Figs. 24e, 25e)3
- 2a. Gills elongate, more than twice as long as wide (Morihara and McCafferty 1979 Fig. 18e); restricted to the Canadian tundra..... *Baetis foemina*
- 2b. Gills not elongate, less than twice as long as wide (Morihara and McCafferty 1979 Fig. 17g); widespread across western North America*Baetis bicaudatus*
- 3a. Antennal scape and pedicel with robust setae (Fig. 9; Morihara and McCafferty 1979 Fig. 18a); paraproct surface with robust setae (Morihara and McCafferty 1979 Fig. 11)4
- 3b. Antennal scape and pedicel without robust setae (Morihara and McCafferty 1979 Figs. 25a, 26a); paraproct surface without robust setae (Morihara and McCafferty 1979 Fig. 10)6
- 4a. Gill margins with large robust setae (Morihara and McCafferty 1979 Figs. 19g, 20g) and serrate or not serrate5
- 4b. Gill margins without large robust setae and serrate (Morihara and McCafferty 1979 Fig. 12)*Baetis tricaudatus*
- 5a. Posterior margins of terga with robust setae (Morihara and McCafferty 1979 Fig. 20f); labial palpi elongate, segment 2 greater than two times as long and basal width of segment 3 (Fig. 10; Morihara and McCafferty 1979 Fig. 20b) *Baetis magnus*
- 5b. Posterior margins of terga without robust setae (Morihara and McCafferty 1979 Fig. 19e); labial palpi not elongate as above, segment 2 less than two times as long as basal width of segment3 (Morihara and McCafferty 1979 Fig. 19a)*Baetis adonis*
- 6a. Gills elongate, more than twice as long as wide (Morihara and McCafferty 1979 Figs. 22e, 23f); principally restricted to Canadian tundra, rarely found in Northeastern Wisconsin and Northern Rocky Mountains of Wyoming.....7
- 6b. Gills not elongate as above, equal to or less than twice as long as wide; widespread.....8
- 7a. Median caudal filament almost equal in length to cerci*Baetis hudsonicus*
- 7b. Median caudal filament approximately 0.5-0.8 length of cerci*Baetis bumdya*
- 8a. Labial palpi slender, segment 2 at least twice as long and basal width of segment 3 (Figs. 4 and 13; (Morihara and McCafferty 1979 Figs. 33c and 36c); inner margin of labial palpi segment 2 convex (Figs. 4 and 13; Morihara and McCafferty 1979 Figs. 33c and 36c).....9
- 8b. Labial palpi more robust than above, segment 2 less than twice as long as basal width of segment 3 (Figs. 15 and 17; Morihara and McCafferty 1979 Figs. 21b, 24c, 25c, 26c); inner margin of labial palpi segment 2 concave (Figs. 15 and 17; Morihara and McCafferty 1979 Figs. 21b, 24c, 25c, 26c)11
- 9a. Caudal filaments with near medial band of darkened segments similar to (Morihara and McCafferty 1979 Figs. 24e, 25e); eastern North American species, with principally Appalachian distribution.....*Baetis phuto*
- 9b. Caudal filaments generally uniform in color, without near medial band of darkened segments; western North American species, west of the Continental Divide.....10
- 10a. Gill I highly reduced or absent (Fig. 5); mandibular incisors with broadened first denticle, approximately as wide as denticle 2 and 3 combined (Figs. 2 and 3).....*Baetis moqui*

- 10b. Gill 1 not highly reduced or absent; mandibular incisor denticulation not as above, denticle 1 approximately equal in width to that of denticle 2 or 3 (Figs. 11 and 12; Morihara and McCafferty 1979 Fig. 33b).....*Baetis alius*
- 11a. Labial palpi with medial lobe of segment 2 moderately developed (Morihara and McCafferty 1979 Fig. 21b); pronotum almost uniformly shaded (Morihara and McCafferty 1979 Fig. 21c).....*Baetis brunneicolor*
- 11b. Labial palpi with medial lobe of segment 2 poorly developed (Figs. 15 and 17; Morihara and McCafferty 1979 Figs. 24c, 25c, 26c); pronotum with inverted U-shaped mark (Morihara and McCafferty 1979 Figs. 24e, 25e, 26d)..... 12
- 12a. Caudal filaments without medial band of darkened segments; abdominal terga with distinctive patterning similar to (Morihara and McCafferty 1979 Figs. 14e, 26e); southwestern species.....*Baetis notos*
- 12b. Caudal filaments usually with medial band of darkened segments (Morihara and McCafferty 1979 Figs. 24e, 25e); abdominal terga not patterned as above, usually similar to (Morihara and McCafferty 1979 Figs. 24e or 25e); principally distributed across eastern North America, rarely found in the Southwest 13
- 13a. Labial palpi segment 3 expanded distomedially, giving an almost truncate appearance (Fig. 15; Morihara and McCafferty 1979 Fig. 24c); glossae with outer margin expanded and well rounded (Fig. 14); darker well marked abdominal terga with three, posterior round, pale areas (Morihara and McCafferty 1979 Figs. 24e); or entirely uniformly shaded with brown.....*Baetis intercalaris*
- 13b. Labial palpi segment 3 not as above, distal margin evenly rounded (Fig.17; Morihara and McCafferty 1979 Fig. 25c); glossae without expanded outer margin (Fig. 16); darker well marked abdominal terga with two large, often kidney-shaped submedial pale areas (Morihara and McCafferty 1979 Fig. 25e).....*Baetis flavistriga*

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LITERATURE CITED

- Doelling, H. H. and G. C. Willis. 1999. Interim geologic map of the Escalante and parts of the Loa and Hite crossing 30' x 60' quadrangles, Garfield and Kane counties, Utah. Utah Geological Survey. Open-File Report 368. 22 pp.
- Gaino, E. and M. Rebora. 1999. Flat-tipped sensillum in Baetidae (Ephemeroptera): a microcharacter for taxonomic and phylogenetic considerations. *Invertebrate Biology*. 118: 68-74.
- Morihara, D. K. and W. P. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). *Transactions of the American Entomological Society* 105: 139-221.
- Waltz, R. D. and W. P. McCafferty. 1987. New genera of Baetidae for some Nearctic species previously included in *Baetis* Leach (Ephemeroptera). *Annals of the Entomological Society of America* 80: 667-670.